MISSISSIPPI RIVER LOCK BUBBLER SYSTEMS AND ILLINOIS WATERWAY STARVED ROCK LOCK

John T. Behrens
CEMVR-ED-DG
(309) 794-5620

INTRODUCTION

Winter navigation on inland waterways pose unique operational challenges for waterways with navigational locks. Particularly, the accumulation of brash ice in the gate recesses can prevent the gates from being opened. This creates navigational delays for barge traffic while lock personnel laboriously work to remove ice from the recesses. This paper is intended to present how the usage of high volume bubbler systems, within Rock Island District, have aided in moving brash ice to assist lock personnel and navigation. The paper will discuss the benefits of bubbler systems, when bubbler systems have been installed, the components for high volume systems, lessons learned from installed systems, the average cost for installation and reference literature to be utilized by future designers of high volume bubbler systems.

HIGH VOLUME BUBBLER SYSTEM BENEFITS

The intention of high volume bubbler systems is to provide lock personnel a means with which they can control ice formation and ice movement. By controlling the formation and movement of ice the efficiency of lockage is improved. The benefits obtained by this increase in efficiency can be identified as follows:

- Since the ice is being controlled and manipulated through the use of the bubbler system, fewer lock personnel are required to assist with the lockage. This allows more time for lock personnel to be available for other duties.

- Bubbler system usage demands less physical work from lock personnel to "Push" ice with long pick poles. This promotes a safer working environment for the employees and higher morale among the workers.

- The time required to perform a lockage during winter ice conditions can be greatly improved by bubbler system use.

- Controlling the quantity of ice against the lock gates reduces wear in the machinery operating the gates. In addition, stresses imposed upon the gate structural members are lower. The benefits are prolonged life of machinery and structural components and extended time between periods of major maintenance.

- Adhesion of ice to the lock structure and gates can be minimized by the melting action associated with the use of high volume bubblers. Ice of varying thickness can be melted in areas contacted by the released air bubbles.

TIME OF INSTALLATION

High volume bubbler systems in Rock Island District have typically been installed as part of lock and dam major maintenance contracts. Including the submerged pipe installation into these multi-million dollar contracts allows the Contractor to take advantage of the lock being dewatered for multiple work items. Therefore, reducing the overall cost to install submerged high volume bubbler piping. The lock chambers are dewatered during these contracts to perform resurfacing of the vertical concrete lock walls and other maintenance. This allows the Contractor sufficient time to install the piping for the gate recess flushing screens and main chamber screen at both sets of gates. The landwall compressor and piping have been installed both as part of the major maintenance contracts and in separate contracts that included the same type of work at multiple sites.

BUBBLER SYSTEM COMPONENTS/SELECTION

Each of the major components of high volume air systems within Rock Island District have been modeled from the research and design calculations conducted by the Cold Regions Research & Engineering Laboratory. The findings of the research laboratory, from a prototype installation at Starved Rock and Peoria Lock, have served as Rock Island District’s basis of design for all subsequent high volume air systems to control ice at locks. The components of each high volume system are described in the headings that follow as they relate to systems installed on the Mississippi River.

COMPRESSOR

The compressors are 150 HP electric motor driven positive displacement rotary screw type. Each compressor is capable of delivering 750 CFM of free air at 100 PSIG full flow and is designed for continuous operation. One compressor serves each bubbler system. The compressor delivers flow to the upstream and downstream gates. Compressor sizing is determined by an iterative air system analysis. The air system analysis determines air discharge rates from orifices in the piping assuming a dead-end pressure. A computer program[1] developed by the Cold Regions Research & Engineering Laboratory is capable of making this simulation to achieve a one-percent difference between the calculated and specified compressor outputs.

SUPPLY PIPES

Supply pipes have consistently been installed with three inch; schedule 40 galvanized steel piping. The piping is routed from a centrally located compressor to each end of the lock chamber. Valve manifolds are installed near the gate recesses to control the delivery of air to each submerged flushing screen. The control valves have typically been three-inch butterfly valves with manual control. Electric control valves were installed at Starved Rock Lock and are well liked by the operators.

FLUSHING SCREEN PIPES

The submerged piping is schedule 40 galvanized steel and varies in size from 3 inch to 1 1/4 inch. The varying size is dependent upon the flushing screen being served and the proximity to the dead-end of pipe. The chamber screen is maintained at 3 inches due to the volume of air being delivered and the distance across the lock chamber. This screen is 96 feet long for a 110 feet wide chamber and is designed with 8-ft orifice spacing. Gate recess screens are supplied with 3-inch piping and reduced accordingly to meet the requirements established by the Cold Regions Research & Engineering Laboratory. The gate recess screens have varying orifice spacing to provide more air near the quoin end of the gate. The orifice spacing follows the recommendations of EM 1110-8-1[2]. Nine orifices are installed along each gate recess-flushing screen.

ORIFICES

Drilled pipe plugs provide the desired quantity of air to the water. The pipe plugs are installed in vertical tee fittings along the horizontal pipe runs. 3/8-inch diameter holes have been determined to deliver the desired quantity of air from the prototype installations. A design flow of 30 ft^3/min per orifice is desired.

CHECK VALVES

Freeze protection of the airlines near the water's surface requires the installation of spring loaded check valves. The check valves are installed near the bottom of the lock chamber in each vertical leg of the air supply piping. Check valves within Rock Island District have had limited success and are subject to periodic maintenance by divers.

LESSONS LEARNED

Seven high volume bubbler systems have been installed within Rock Island District over the last 15 years. During that period, experience has been gained to improve the design of each subsequent bubbler system installation. Design enhancements that have been incorporated into the designs include:

- Low ambient temperature compressor enclosures are specified to permit operation in ambient air temperatures as low as minus 20 degrees Fahrenheit.

- Compressor lubricant is specified to be food grade polyalphaolefin to be environmentally friendly.

- Consideration must be given to accommodate both the electrical load from the lock and dam and the electrical load of the compressor. Back-up generators may not be sized properly to operate both. Rock Island District’s back-up generators are not wired or sized to operate the compressors. The compressors were not considered to have critical loads.

- Check valves within the vertical piping have not been 100% reliable and freezing in the pipes has been experienced. To combat the freezing potential piping manifolds are installed with isolation valves, cross fittings and pipe plugs to allow lock personnel to either charge the vertical piping with air or fill them with environmental RV antifreeze. Charging the piping with air forces the static water level below the freezing surface and is the preferred method.

- Ball valves or positional butterfly valves with 90 degree full open to full close operation are best suited to deliver the air to the bubbler screens. These valves are preferred over gate valves by lock personnel.

- Ultra violet protection is required for all exposed compressor controls to prevent deterioration.

- A consideration for future designs is zebra mussel remediation. It has been discovered that current systems are experiencing interior pipe fouling from zebra mussels. Increased periodic operation is being employed in attempt to flush the juvenile mussels from the orifices before they are allowed to reach adulthood. The mussel problem has not been fully researched at this time and more permanent measures will be incorporated, as they become known.

BUBBLER SYSTEM INSTALLATION COST

Within Rock Island District bubbler system installation costs for the 5 most recent installations have averaged $170,285. This averaged cost does not include the cost for air piping installed within the lock chamber. The piping in the lock chambers for these locations was installed as part of the major rehabilitation contracts. Air piping installed within the lock chambers as part of the major rehabilitation contracts averages $93,248. The cost associated with dewatering a lock chamber has been determined to be $606,622. This cost is averaged from 21 different contract lock dewaterings. Some of these contracts included bubbler system installation.

DESIGN REFERENCES

Rock Island District has been very successful with the design and operation of installed high volume bubbler systems. The success is due in part to the early research conducted within Rock Island District by the Cold Regions Research & Engineering Laboratory. Technical information available for designers considering installing high volume bubbler systems includes EM1110-8-1(FR) Winter Navigation on Inland Waterways[2] and the

Cold Regions Technical Digest, No. 83-1, March 1983, Melting Ice with Air Bubblers[3]. These two documents provide valuable guidance in designing high volume bubbler systems and the theories involved with using air to melt ice.

CONCLUSION

Brash ice at the lock sites of the Corps creates annual operational challenges. The challenges test the personnel working with the ice physically and emotionally. The ice also places additional demand on the machinery and gate structural members to carry the additional load. With the continuing environmental clean up of our inland waterways brash ice is more likely to form in the future and pose operational difficulties. The use of high volume compressed air systems can provide the effective means to control the annual occurrence of brash ice.

REFERENCES

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AUTHOR’S ADDRESS

AUTHOR’S ADDRESS: US Army Corps of Engineers
Rock Island District
P.O. Box 2004, Clock Tower Building
Rock Island, IL 61204
http://www.mvr.usace.army.mil